

area, there was a Madreporarian fauna there which was singularly like unto that which followed it, both as regards the shape of the forms and their genera. Still earlier, during the slow subsidence of the great Upper Cretaceous deep-sea area, there was a coral-fauna in the north and west of Europe, of which the existing is very representative. The simple forms predominate in both faunas. *Caryophyllia* is a dominant genus in either; and a branching *Synhelicia* of the old fauna is replaced in the present state of things by a branching *Lophohelia*. The similarity of deep-sea coral-faunas might be carried still further back in the world's history; but it must be enough for my purpose to assert the representative character and the homotaxis of the Upper Cretaceous, the Tertiary, and the existing deep-sea coral-faunas. This character is enhanced by the persistence of types; but still the representative faunas are separable by vast intervals of time.

MISCELLANEOUS.

On Parthenogenesis in Polistes gallica. By Prof. C. T. VON SIEBOLD.

As long ago as 1858, Leuckart ascertained that the workers in societies of humble bees and wasps lay eggs, and that these eggs are capable of development. Von Siebold has resumed these experiments upon *Polistes gallica*. This wasp is peculiarly suitable for such investigations, because its nest consists of a single comb entirely exposed. The comparative imperfectness of this nest allows the observer to follow all the actions of its inhabitants and all the phenomena which take place in its cells. Von Siebold succeeded in fixing great numbers of colonies of *Polistes* in places selected by him. He even succeeded in making these nests moveable for the purpose of experiment, without causing their inhabitants to abandon them. In this way he was able to observe hundreds of colonies of *Polistes* from their origin to their extinction.

One nest of *Polistes* suffices for an entire summer for a colony, which it serves as a habitation and nursery. In the autumn all the colonies perish, however numerous they may be. Every spring isolated females give origin, each for itself, to new colonies. These females were produced during the previous summer, which they passed in a virgin state, and were fecundated by copulation in the autumn before falling into their winter sleep. The spermatozoids stored in the seminal receptacle are preserved in good condition throughout the winter, and in spring fertilize the eggs as the deposition of the latter goes on. Each of these females constructs for itself a nest composed of a small number of cells, and busies itself at first with oviposition, and then with the bringing up of the new generation. The new individuals thus engendered are, up to the middle of summer, exclusively females. The first of these individuals, reared by isolated mothers, are females of very small size. Their smallness is no doubt due to the circumstance that the mother, being

overwhelmed with work, can only furnish her young with a scanty supply of nourishment. These small individuals have hitherto been regarded as workers or neuters; but this denomination is erroneous. Von Siebold has dissected many of these small individuals of *Polistes*, and ascertained, by the examination of their generative apparatus, that they are not, like the worker bees, females arrested in their development, but perfectly developed females the turgid ovaries of which are filled with eggs ready to be laid.

As soon as the original mothers have thus produced assistants in the form of these active virgins, the increase of the nest takes place rapidly, and the larvæ, receiving more abundant nourishment, are transformed into wasps as large as their mother. Towards the end of June or the beginning of July the comb presents a large surface and is composed of a very great number of cells. At this period some male individuals may be remarked for the first time among the numerous large and small females. Their number soon increases considerably. The observation of these facts suggested to Von Siebold that there might exist, in *Polistes*, a division of physiological labour—in this sense, that the fecundated females of the preceding year produce only female eggs, whilst the virgins of the new generation produce male eggs parthenogenetically. This hypothesis seemed to find support in the small number of ovarian tubes in *Polistes*, which can only produce an inconsiderable number of eggs.

Experiment has confirmed this hypothesis in the most striking manner. Von Siebold selected a certain number of nests in the spring, at a period when the mothers had already reared one or two assistants. He removed from these nests the mothers, and dissected them in order to ascertain the condition of their generative organs. He always found the ovarian tubes in full activity, and the seminal receptacle full of mobile spermatozoids. At the same time he entirely emptied all the cells of these nests which contained eggs or any small larvæ, preserving only the larvæ of large size. Notwithstanding the disappearance of the mothers, the little virgins continued to take care of the larvæ which had been preserved, and consequently the colonies did not perish. Von Siebold took the precaution to mark, in each of the nests experimented upon, the occupied and empty cells. In a few days he perceived that some of the latter contained eggs. Careful examination even enabled him to surprise some of the little virgin wasps at the moment when they were ovipositing at the bottom of a cell. These individuals were at once sacrificed, when the six ovarian tubes were found to be completely developed, filled with ova in different stages of growth, whilst the seminal receptacle was perfectly formed but completely empty.

During this time, thanks to the assiduous care of the young virgins, new female individuals, produced from the large larvæ which had not been sacrificed, arrived at their complete development, and at once took part in the labours of the society. The nests were consequently enlarged by new cells, which were speedily occupied by eggs laid by the virgins. All these eggs (and this is the important fact) were developed notwithstanding the absence of fecundation, and gave

birth to young larvæ which prospered under the care of the virgin society. All these larvæ, at their final transformation, furnished males, in opposition to the larvæ which had been previously produced by the original mother, and which had furnished only females.

It may, perhaps, be asked whether a strange fecundated mother may not have penetrated accidentally into the nests deprived of their mother, and oviposited here and there in the cells. To this question Von Siebold gives a decided negative. During the four years which he has devoted to the study of these wasps, he has constantly ascertained that the inhabitants of one nest never tolerate the intrusion of a *Polistes* from another colony into their society. The instinct of these Hymenoptera informs them that these intruders are only robbers penetrating into their nest to steal the larvæ and devour them. It is therefore evident that in *Polistes gallicæ* the male individuals originate parthenogenetically from unfecundated eggs.—*Zeitschr. für wiss. Zoologie*, Bd. xx. p. 236; *Bibl. Univ.* March 15, 1870, *Bull. Sci.* p. 271.

On Force and Will. By B. A. GOULD.

Scientists are now of accord that "force can neither be created nor destroyed," and that "the quantity of force in nature is just as eternal and unalterable as the quantity of matter." Its various forms are eminently convertible, yet utterly indestructible. And to avoid that fruitful source of disagreement among the ablest men, which has arisen from the ambiguous signification of the word, we must adopt the meaning which is finding general acceptance, and define force as "that which is expended in producing or resisting motion"—thus clearly discriminating between force and its cause.

In his retiring address before the American Association last year, our honoured ex-president Dr. Barnard presented an argument, so vigorous and clear that I see no room for an adequate rejoinder, in opposition to the doctrine which would extend the principle of the conservation of force to the phenomena of consciousness—"a philosophy which at the present day is boldly taught in public schools of science, and which numbers among its disciples many very able men." He says, for instance:—

"Organic changes are physical effects, and may be received without hesitation as the representative equivalents of physical forces expended. But sensation, will, emotion, passion, thought are in no conceivable sense physical" (*Proc. Amer. Assoc. Chicago*, p. 89).

"The philosophy which makes thought a form of force, makes thought a mode of motion, converts the thinking being into a mechanical automaton, whose sensations, emotions, intellections are mere vibrations produced in its material substance by the play of physical forces, and whose conscious existence must for ever cease when the exhausted organism shall at length fail to respond to these external impulses" (*ibid.* p. 91).

"Thought cannot be physical force, because it admits of no measure. * * * A thing unsusceptible of measure cannot be a quan-